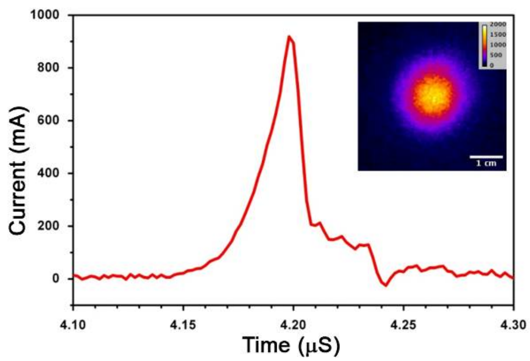
AFRD newsletter *June 2014*

Science with intense, pulsed ion beams from NDCX-II



After more than a year-long break in funding, the DOE Office of Fusion Energy Sciences is supporting research on the Neutralized Drift Compression Experiment (NDCX-II). When the build-out phase is complete, NDCX-II will deliver intense, short ion bunches with a kinetic energy of 1.2 MeV. With focusing and drift compression this will enable uniform heating of ~ 2 micron thick targets to $\sim 1\,\mathrm{eV}$ temperature with $\sim 1\,\mathrm{ns}$ ion bunches. While the achievable target temperature at NDCX-II is much lower than what can be achieved with intense laser pulses, the excited volume is relatively large and uniformly heated, which enables precision diagnostics of the transient warm-dense-matter state.

The high degree of tunability and control in ion species (e.g., He, Li, K, Cs), kinetic energy (0.1 to 1.2 MeV), spot size ($< 1\,\mathrm{mm}^2$ to $10\,\mathrm{mm}^2$) and pulse length (<1 ns to 600 ns) allows us to tune excitation conditions across three physical regimes: from isolated collision cascades, through the onset of order-disorder phase transitions, to warm-dense-matter states. One particularly interesting application for fusion energy is systematic pump-probe study of the dynamics of radiation-induced defects of fusion materials. This is enabled by the high repetition rate of two pulses per minute of short ion pulses, as well as by the way ions interact with the material being tested. Pump-probe studies with lasers are useful for tracking electron dynamics and ensuing heating. At NDCX-II ions couple also directly to the material's lattice through elastic collision processes. With varying ion beam conditions, partitioning into electron and elastic energy deposition processes can be tuned. This opens the path to *in-situ* studies of damage cascade and dynamic annealing. The range of energy deposition regimes allows varied studies, from dilute cascades to probe light ion damage (and mimic neutron damage) to very dense cascades similar to those caused by fission fragments and high-Z cosmic rays.

Understanding the multi-scale time evolution of radiation damage, from picoseconds to seconds, is of fundamental importance for our understanding of radiation effects in natural processes. It can aid the development of advanced materials for use in high radiation environments (including fusion reactor components, fission reactor materials, and space electronics). Further, we aim at first-in-class *in-situ* data on short time scales to experimentally benchmark simulation tools that are widely used to predict the evolution of radiation damage in materials.

Pushing the capability to control very intense, space-charge-limited ion beams will help lay the foundation for potential drivers for inertial fusion energy and, generally, inform the development of ion beam technologies at the intensity limits. This will be useful for a wide range of applications in high energy physics, medicine, materials processing and national security.

Daniele Filippetto receives DOE Early Career Research Program Funding

Recently, the DOE's Office of Science selected 35 scientists from across the US to receive funding as part of the DOE's Early Career Research Program. Among those selected was AFRD's Daniele Filippetto.

His project aims to develop an innovative tool for ultrafast science that will provide access to four-dimensional visualization of atomic and molecular dynamics. A high-brightness, high-repetition rate electron source will be used to produce relativistic femtosecond pulses with high peak and average flux. An electron diffraction beamline will deliver electron pulses to the sample for pump-probe experiments at high repetition rate (up to MHz). Ultrashort pulses will provide direct access to femtosecond dynamics, and the high electron flux will enhance the spatial accuracy, enabling dynamical studies of complex molecules in gas and liquid phases. The instrument will combine high accelerating fields, relativistic energies, and high repetition rate to tackle most of the issues limiting the resolution of ultrashort electron probes, such as pump-probe velocity mismatch, time and pointing jitters, and low signal-to-noise ratio. The blending of time resolution and high dose rate at the sample will have an enormous impact on many different fields of science, unveiling the connections between the structure and the function of biological systems, enhancing our understanding of chemical and biochemical reactions, and following transformation pathways that could ultimately lead us to more efficient energy storage and clean energy production.

Get to Know Your Colleague: Chuck Swenson

What is your current position and what are you working on right now?

I am an engineer/scientist responsible for the Magnet and Vacuum Systems Group at ALS. I am working on the COSMIC EPU project, as well as the ALS-U *(a future upgrade now taking shape)* and a series of scoping studies for a hard x-ray undulator for the ALS protein crystallography program. Bit by bit I am picking up parts of ALS operations.

Have you done other things at the Lab prior to your current activites?

I led the team that put together and installed the MAESTRO EPU on the ALS.

What is your professional background? Where did you work before coming to the Lab?

I was trained as an accelerator physicist. I started my career at Westinghouse working on rapid cycling dipole magnets for the Superconducting Super Collider High Energy Booster. I worked at the US National High Magnetic Field Laboratory in Tallahassee and at Los Alamos National Laboratory. I ran the pulsed magnet group at Los Alamos for about 10 years. I have helped design & build a 10 cm bore 900 MHz NMR magnet as well as several ultra-high-field pulsed magnet, culminating with the 100 T nondestructive pulsed magnet.

Where are you from originally? Where did you go to college or university?

I was born in Columbus, Ohio. I grew up in South Texas after leaving the rust belt in the early 1970s. I went to university at Baylor, and did my Ph.D. dissertation at Texas A&M.

Ever had something go spectacularly wrong?

Once I had a suspicious coil assembly fail during a QA test. The component was flawed in that it did not pass all isolation tests due to a poor dielectric design. My management was pushing to use the assembly as these items were not cheap. The component had already passed an revised QA test. However, the test documentation was really poor. I insisted on a second series of pulsed power tests. I was about 25 feet away when the device faulted, dumping about 2 MJ of energy into an air arc. This kind of thing is very loud even when there is a blast shield between you and the arc. I walked around like a rabbit for a couple of days. We built a new coil without the design flaw and were successful. I think we dodged a 10 M$ bullet that day.

If you could have dinner with three famous persons from the past or the present, who would it be?

I like to watch how people's minds work to solve problems. My ideal meal would be with Richard Feynman, Ben Franklin, and Hedy Lamarr at the Tonga Room in the City. There is no telling where the conversation would go.

With which scientist (past or present) would you like to discuss their work?

I would very much like to have had the opportunity to work with Enrico Fermi. He had the ability to approximate almost anything.

What's on your MP3 player? What did you last listen to?

Lots of reggae. Last song on the iPhone: "Late for the Sky" Jackson Browne

Link of the Month: Video Feed From the ISS And See it Fly Over

You probably have seen pictures of the earth taken from the International Space Station (ISS). If you want to look at plenty more and try to figure out what you are seeing, go to this link: `http://m.ustream.tv/channel/iss-hdev-payload` which is a live video feed from the ISS.

Did you know that you can see the ISS flying overhead, typically either soon after sunset or just before sunrise? Go here: `http://spotthestation.nasa.gov/` to subscribe to a mailing list which will send you emails when you can see the ISS at your location. In the Bay Area you can see it a few times per month which tend to come in clusters on consecutive days with weeks in between.

Thanks to Thomas Schenkel and Peter Seidl for the report on NCDX-II, and to Chuck Swanson for "Get to Know Your Colleague". Thanks to Joe Chew and Sam Vanecek for editing/proofreading.

Please send suggestions for news items, links or "get to know your colleague" to Ina Reichel (`IReichel@lbl.gov`).